Coastal and Submesoscale Process Studies for ASIRI

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LONG-TERM GOALS

To determine how one-dimensional and three-dimensional mixing and advective processes in the upper ocean in the Bay of Bengal influence the Monsoon.

OBJECTIVES

We will conduct process studies to examine and evaluate lateral and vertical routes for dispersal of the freshwater in the Bay of Bengal.

APPROACH

We propose evaluating the one-dimensional balance at the RAMA mooring at 15N to ascertain whether three dimensional processes are important. We will also use the existing ARGO profiles to get an idea of the horizontal buoyancy gradients in the Bay of Bengal. These would be useful for process experiments.

Several numerical experiments over a range of scales and outlined as follows:

i. With strong surface freshwater stratification and a barrier layer, forced by winds, and with mixing modeled by a dynamic subgrid closure scheme to examine the vertical mixing in response to surface forcing.

ii. With a coastal buoyant current against steep topography, forced by winds, to examine the instabilities of the current in response to wind-driven up-/down-welling.

iii. With a wind stress curl to generate a cold upwelling feature to examine the stability of the cold dome.

iv. With high resolution winds that resolve the near-inertial motion and a diurnal heat flux. This would ascertain whether the near-inertial mixing is important and rectification effects can change the mixed layer structure.

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v. Offshore mesoscale eddies interacting with the coastal current

PRELIMINARY RESULTS

Manita Chouksey, a summer intern MTech student from IIT BBS India visited Tandon's laboratory in summer 2013 and worked with him on data from 15N RAMA mooring. Using the COARE3.0 algorithms to construct air-sea fluxes, and using PWP mixed layer model, the results show that model characteristics begin to diverge from the data, and beyond a few days, advective processes become important at this location. Manita is now focusing on the effect of optical characteristics on the upper ocean modeling.

Postdoc Dr. Sanjiv Ramachandran and the PIs analyzed depth-averaged lateral gradients in the bay using Argo profiles for the months of October, November and December. We chose two regions for the analysis, one in the open ocean (88-90E, 9-12N) and one closer to the coast (87-92E, 15-18N). The lateral gradients increase with decreasing scale (Fig.1) for all three months, from O(10^{-8} s^{-2}) at scales O(100km) to O(10^{-6} s^{-2}) at scales O(1-10km). This is true for the gradients averaged two different depth ranges, 0-20m and 20-100m. At smaller scales (O(1-10km)) the gradients in the region close to the coast typically tend to exceed those in the open ocean. The large lateral gradients in the upper ocean strongly suggest O(1—10km) submesoscale frontal processes may be important in the North Bay. Such processes have been found to be vital to the upper-ocean dynamics in the North Atlantic and the Kuroshio. Compared to these regions, our estimated values of the lateral gradients in the upper 20m are significantly larger, hinting potentially at an even greater role for submesoscale physics in the coastal BoB. The baroclinicity at depth (100m) could give rise to coupling between the fast submesoscale modes in the upper ocean and the slower mesoscale dynamics below.

The T-S structure for these months (Fig.2) shows the formation of a temperature inversion by December, probably due to the creation of a barrier layer. The inversion gets stronger as we approach the coast. Another interesting feature revealed in the T-S diagram is the presence of compensating gradients in December, clearer in the top panel of Fig. 2. The large influx of freshwater from river run-off into the bay creates strong gradients in the salinity field, and consequently, the buoyancy field. Such gradients, however, can be erased rapidly on inertial time scales by frontal, submesoscale processes which are efficient in converting the available potential energy residing in the lateral gradient to kinetic energy.

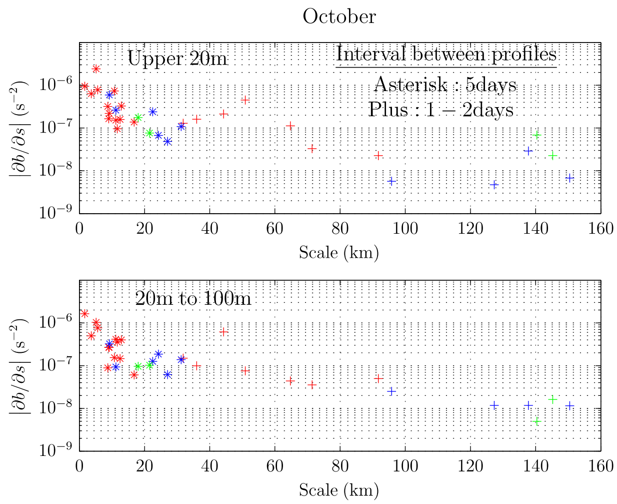

Figure 1 Lateral buoyancy gradient versus scale based on Argo float profiles within 1-2 days and within 5 days. The buoyancy gradients are very significant at scales of less than 30km in the upper 100m.

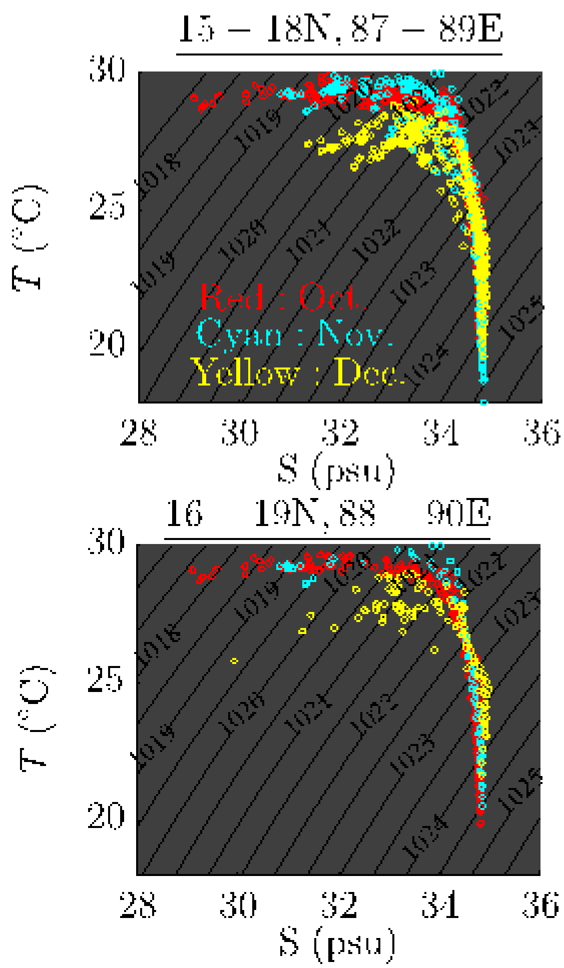

Figure 2 T-S structure in selected region of the Bay based on ARGO float profiles, showing temperature inversion in December profiles (barrier layer) and compensated gradients.